2009 TRB Annual Meeting DVD
Papers related to ongoing WHRP projects

0092-08-08 Reduction of Minimum Required Weight of Cementious Materials in Concrete Mixes

Strength and Stiffness of Recycled Base Materials Blended with Fly Ash
Felipe Filizzola Camargo and Tuncer B. Edil, University of Wisconsin, Madison; Craig H. Benson, University of Washington
Paper Number: 09-0358
From: Abstract
Properties of a recycled pavement material (RPM) and a road surface gravel (RSG) stabilized with a Class C fly ash are compared to the properties of a conventional base material (Minnesota Class 5 base). California bearing ratio (CBR), resilient modulus (Mr), and unconfined compressive strength (UCS) tests were conducted to evaluate the effects of adding fly ash to the RPM and RSG to enhance their mechanical properties. Freeze-thaw durability was evaluated in terms of Mr and UCS. CBR, Mr, and UCS for RPM and RSG increased with fly ash content. Mr and UCS for RPM and RSG increased with curing time, with significant gains occurring after 7 and 28 d of curing. Addition of fly ash reduced plastic strains of the recycled materials during resilient modulus testing. Freeze-thaw cycling had a small effect on the Mr and UCS of the recycled materials. A strong relationship was found between summary resilient modulus (SRM) and UCS of recycled materials blended with fly ash, suggesting that the SRM can be estimated from a UCS test.

Performance Assessment of Cementitiously Stabilized Subgrade Soils
Pranshoo Solanki and Musharraf M. Zaman, University of Oklahoma; Naji Khoury, Temple University
Paper Number: 09-0288
From: Abstract
A laboratory study was undertaken to evaluate the performance of two cementitiously stabilized subgrade clays from Oklahoma. Three different percentages of locally used and economically available stabilizers in Oklahoma, namely, hydrated lime, class C fly ash (CFA), and cement kiln dust (CKD) were used. Cylindrical specimens were prepared with different percentages of stabilizers and cured for 28 days at a constant temperature and controlled humidity. Following the curing period, specimens were tested for unconfined compressive strength (UCS), representing short-term behavior. Long-term laboratory performance (or durability) was assessed in terms of moisture susceptibility (tube suction test) and threedimensional (3-D) swell during 60 days of capillary soaking. Short-term performance results showed that specimens prepared with 15% CKD exhibited the highest improvement in UCS values of both clays. On the other hand, long-term performance results projected lime on the top by reducing moisture susceptibility and swelling potential of specimens; however, contrary to short-term performance, CKD showed poor long-term performance.

Blended Fine Aggregates in Pavement Concrete
Alison Trachet, Nelson Architectural Engineers; David Fowler, University of Texas; Eric Koehler, W.R. Grace & Co.
Paper Number: 09-2642
From: Abstract
Manufactured fine aggregate (MFA) can be used as a replacement for or in conjunction with natural sand in concrete mixtures. MFA does not exhibit ideal shape or texture for fine aggregate, and the production of MFA generates high percentages of microfines, particles that pass the No. 200 sieve. Microfines are

washed from the aggregate due to specification limitations, resulting in wasted aggregate and a coarser fine aggregate grading. Three manufactured sands were incorporated into concrete mixtures to determine their effects on fresh and hardened concrete properties. It was found that greater proportions of manufactured sand caused the workability to decrease, the demand for high-range water-reducing admixture to increase, and the compressive strength to increase.

Examination of Steel Slag as a Replacement for Natural Aggregates in Concrete Paving Mixtures
Richard S. Obratil, Matthew A. Pastorelle, Paul A. Bosela and Norbert J. Delatte, Jr., Cleveland State University
Paper Number: 09-1291
From: Abstract
Meeting the ever increasing global demand for concrete is becoming more challenging with each passing year. With more than three quarters of the volume of concrete commonly composed of aggregates and the realization that the Earth's resources are finite, finding suitable alternatives to natural aggregates has become increasingly important. This research was undertaken to explore the feasibility of utilizing the steel slag produced by steel mills in the Northeastern Ohio region as a replacement for natural aggregate in the Ohio Department of Transportation (ODOT) Class C concrete pavement mixture. Ohio is still one of the top three steel producers in the United States. Steel slag is produced in Basic Oxygen (BOF) and Electric Arc (EAF) furnaces during separation of the molten steel from impurities. Exact worldwide production numbers of steel slag are currently unavailable, however it is estimated that 130 to 200 million tons of steel slag was produced in 2007. The primary aim of this research was to examine the effects of rapid freezing and thawing on concrete specimens since any concrete pavement utilized in the region is subjected to these harsh effects. Length change of the hardened concrete was also examined as well as the compressive, flexural, and splitting tensile strengths of the various replacement mixtures. Completion of the testing program demonstrated the concrete mixtures ability to withstand the effects of the 300 required rapid freeze thaw cycles. However, further testing is required to properly examine the aggregates expansive properties.

Recycling and Utilizing Waste Glass as Concrete Aggregate
Farshad Rajabipour, Seth Goodnight, Alison Leake and Ethan Smith, University of Hawaii; Gregor Fischer and Porunn Sigurdardottir, Technical University of Denmark
Paper Number: 09-2195
From: Abstract
Application of crushed recycled glass as concrete aggregates offers significant benefits towards sustainability by diverting waste from landfills and utilizing it in manufacturing value-added products. In areas with limited availability of durable natural aggregates, using locally recycled glass can reduce the cost and environmental impact of importing aggregates from elsewhere. However, the main challenge is the deleterious alkali-silica reactivity (ASR) of glass aggregates in concrete. To develop durable concrete products, this study evaluates the effectiveness of several ASR mitigation strategies in mortars containing recycled glass sand. The ASR mitigation methods studied include proper selection of glass type, content, and particle size, application of fly ash and lithium-based ASR inhibitors, and application of air entrainers, shrinkage reducers, and fiber reinforcement. The results show that recycled glass sand smaller than #30 sieve or with average particle size smaller than 0.5mm is innocuous in replacement levels as high as 50% of the natural sand. Also, ASR expansion can be effectively controlled by using 20% class F fly ash. When glass sand was used in concrete in replacement levels of up to 75%, a moderate strength reduction (5-14%) was observed. Also, the influence on fresh properties (slump and air content) was modest. These results provide guidance on proper mixture proportioning of concrete containing recycled glass aggregates. TRB

Properties of Concrete Incorporating Ultrafine Fly Ash and Silica Fume
Akhter B. Hossain, Sandeep Shrestha and James Summers, University of South Alabama

Paper Number: 09-0686

From: Abstract

This paper describes a laboratory study on the influence of the combination of ultrafine fly ash (UFFA) and silica Fume (SF) on the properties of fresh and hardened concrete. The paper also compares the performance of the concrete incorporating UFFA and SF (ternary blend of cement), the concrete incorporating UFFA or SF (binary blend of cement), and control Portland cement concrete. The test results show that the incorporation of silica fume or ultrafine fly ash in concrete resulted in higher strength and improved durability (resistance to chloride penetration). These benefits were found to be more pronounced in the SF concrete. However, the SF concrete demonstrated several limitations such as low slump, and high early age shrinkage. These limitations were not observed in the UFFA concrete; addition of UFFA increased the slump and decreased the early age shrinkage. In order to minimize the shortcomings of SF without loosing its strength and durability benefits, a concrete mixture was prepared incorporating both SF and UFFA. The test results show that the incorporation of both SF and UFFA produced a concrete mixture that demonstrated high early age strength and improved durability similar to the SF concrete. In addition, unlike SF concrete, the new concrete mixture demonstrated higher level of slump and lower level of free shrinkage.